Using Generic Data to Establish Dormancy Failure Rates

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Dormancy Failures

Suppose a probabilistic risk assessment includes some items that are subject to a significant dormant period prior to being operated (e.g., a mission to Mars).

One would expect the failure rate to be lower during a dormant period. But by how much?

An order of magnitude?
A factor of 30?

$$d = \frac{f_{Active}}{f_{Dormant}}$$

The goal is to find a data-based source for **dormancy factors**; the dormancy factor is the ratio of the dormant failure rate to the combined active failure rates.

Possible Sources

- Non-Operational Databases (NONOP-1, 1987)
- MIL-HDBK 217
- 217Plus
- Various Conversion Factors

Conversion factors are typically intended to be used on electronic piece parts.

NPRD-2011 (Nonelectronic Parts Reliability Database)

- Some items contain the dormant environment
  - About 120, a very small percentage of the total number of items
- Probably not the items you are looking for

Dormant GRADS
(Generic Risk Analysis Data Set)

Special Selections

Select/Deselect All Data Sheets ☐
Show Database Summay Sheet ☑

Show/Hide Data Sheets

DORMANT GRADS

Generic Risk Analysis Data Set

Version: 1.0
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A-C

Data Sheet Name	Show
Accelerometer	☐
Accumulator,Press,Hyd	☐
Actuator	☐
Actuator,Hydraulic	☐
Actuator,Linear	☐
Actuator,Pneumatic,Linear	☐
Antenna	☐
Arrestor,Surge,Spark Gap	☐
Attenuator	☐
Bearing	☐
Bearing,Ball	☐
Bellows	☐
Circuit Breaker	☐
Circuit Card Assembly,Populate	☐
Circuit Card Assmbly,Pop,Plated	☐
Connection,Solder	☐
Connection,Solder,Hand Lap	☐
Connector,Circular	☐
Connector,Circular,Multi-Cont	☐
Connector,Coaxial,FRRF	☐
Connector,Electrical	☐
Connector,PCB, Printed Circuit	☐
Connector,PWB, Printed Wiring	☐
Connector,Rectangular	☐
Counter,Timer	☐
Coupler,Antenna	☐
Coupler,Directional	☐
Crystal,Quartz	☐

D-H

Data Sheet Name	Show
Disk Drive,Floppy	☐
Disk Drive,Hard Disk	☐
Duct	☐
Duct,Air,Furnace	☐
Electron Tube	☐
Electron Tube,CRT	☐
Electron Tube,Klystron	☐
Electron Tube,Magnetron	☐
Engine	☐
Fan	☐
Fan,Axial	☐
Fan,Centrifugal	☐
Fasteners and Hardware	☐
Filter,Bandpass	☐
Filter,Fluid,Pressurized	☐
Fitting,Hydraulic,QD	☐
Flight Instrument	☐
Fuse,Enclosed Link	☐
Gas Generator	☐
Gasket	☐
Generator	☐
Generator,AC Voltage	☐
Generator,Gas Turbine	☐
Generator,Turbine	☐
Gyroscope	☐
Gyroscope,Rate	☐
Heater,Electrical,Resistive	☐
Hose,Hydraulic	☐

I-R

Data Sheet Name	Show
Igniter	☐
Igniter,Explosive	☐
Igniter,Explosive,Bolt	☐
Igniter,Explosive,Solid Prop	☐
Igniter,Explosive,Squib	☐
Inductive Device,Inductor,Micr	☐
Lamp,Neon,Miniature	☐
Manifold,Fluid	☐
Motor,AC	☐
Motor,Sensor	☐
Motor,Torque	☐
Motor Generator	☐
PCB, Printed Circuit Board,Pop	☐
PCB, Printed Circuit Board,Unp	☐
Pin,Connector	☐
Power Transmitter	☐
Pump,Hydraulic	☐
Pump,Hydraulic,Centrifugal	☐
Pump,Hydraulic,Fuel	☐
Pump,Hydraulic,Gear	☐
Pump,Hydraulic,Piston	☐
Pump,Hydraulic,Vane	☐
Recorder	☐
Regulator,Pressure,Hydraulic	☐
Relay,Electromagnetic	☐
Relay,Electromechanical,Gen	☐
Relay,Electromechanical,Latch	☐
Relay,Electromech,Reed,Dry	☐
Relay,Power	☐
Relay,Solenoid	☐
Relay,Thermal	☐

S

Data Sheet Name	Show
Seal	☐
Seal,O-Ring	☐
Seal,Packing	☐
Sensor,Motion,Acc,Angular	☐
Sensor,Motion,Acc,Linear	☐
Sensor,Motion,Acc,Pendulum	☐
Sensor,Pressure	☐
Sensor,Transducer	☐
Sensor,Transducer,Motion	☐
Solenoid	☐
Spring	☐
Switch	☐
Switch,Electronic	☐
Switch,Inertial	☐
Switch,Micro	☐
Switch,Pressure	☐
Switch,Pushbutton	☐
Switch,Rotary	☐
Switch,Rotary,Stepping	☐
Switch,Sensitive	☐
Switch,Sensitive,Micro	☐
Switch,Thermostatic	☐
Switch,Toggle	☐
Synchro,Resolver,Low Speed	☐

T-Z

Data Sheet Name	Show
Tank,Pressurized,Gas	☐
Transformer	☐
Transformer,Power,Single Phase	☐
Transformer,Power	☐
Transformer,Pulse	☐
Transformer,RF, Radio Freq	☐
Valve,Ball,Hydraulic	☐
Valve,Bypass,Hydraulic,Fuel	☐
Valve,Check,Hydraulic	☐
Valve,Check,Pneumatic	☐
Valve,Hydraulic,Solenoid	☐
Valve,Relief,Hydraulic	☐
Valve,Relief,Pneumatic	☐
Valve,Shut Off,Hydraulic	☐
Valve with Actuator,Pneumatic	☐

Dormant GRADS—Continued

The dormancy factor for the gyroscope is: $d = \dfrac{2.0\times10^{-5}}{2.5\times10^{-7}} = 80.0$

Gyroscope **GRADS Rate Based Data Sheet (per hour)**

Environment	Count	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
		Mean	Error Factor	α	β	SD	Variance
Overall	1	2.0E-05	9.6	1.8E-01	9.0E+03	4.7E-05	2.2E-09
ARW	1	1.0E-04	3.9	1.0E+00	1.0E+04	1.0E-04	1.0E-08
AUF	1	4.3E-06	5.6	5.0E-01	1.2E+05	6.0E-06	3.7E-11
GF	1	1.8E-05	2.4	3.0E+00	1.6E+05	1.1E-05	1.1E-10
SF	3	5.1E-06	5.9	4.5E-01	8.7E+04	7.7E-06	5.9E-11
A	1	7.8E-06	5.6	5.0E-01	6.4E+04	1.1E-05	1.2E-10
G	1	1.8E-05	5.6	5.0E-01	2.7E+04	2.6E-05	6.7E-10
GB	1	1.5E-05	5.6	5.0E-01	3.3E+04	2.1E-05	4.5E-10
DOR	1	2.5E-07	1.2	1.3E+02	5.2E+08	2.2E-08	4.8E-16
Dormant Environment Records (DOR)	**1**	**Records Used**		**9**	**Failures Used**		**9.0**

Data Sources

Name	Quality	Environment	Source	Failures	Hours	Mean	Variance
Gyroscope	Military	ARW	NPRD-091	1	10,000	1.0E-04	1.0E-08
Gyroscope	Military	AUF	16953-000	0	117,000	4.3E-06	3.7E-11
Gyroscope	Military	GF	NPRD-061	3	164,000	1.8E-05	1.1E-10
Gyroscope	Military	SF	10219-034	2	508,000	3.9E-06	7.8E-12
Gyroscope	Military	SF	NPRD-077	0	63,000	7.9E-06	1.3E-10
Gyroscope	Unknown	A	14182-001	0	63,865	7.8E-06	1.2E-10
Gyroscope	Unknown	G	14182-001	0	27,333	1.8E-05	6.7E-10
Gyroscope	Unknown	GB	27027-000	0	33,333	1.5E-05	4.5E-10
Gyroscope	Unknown	SF	14182-001	0	142,735	3.5E-06	2.5E-11
Gyroscope	Military	DOR	13253-000	128	518,000,000	2.5E-07	4.8E-16

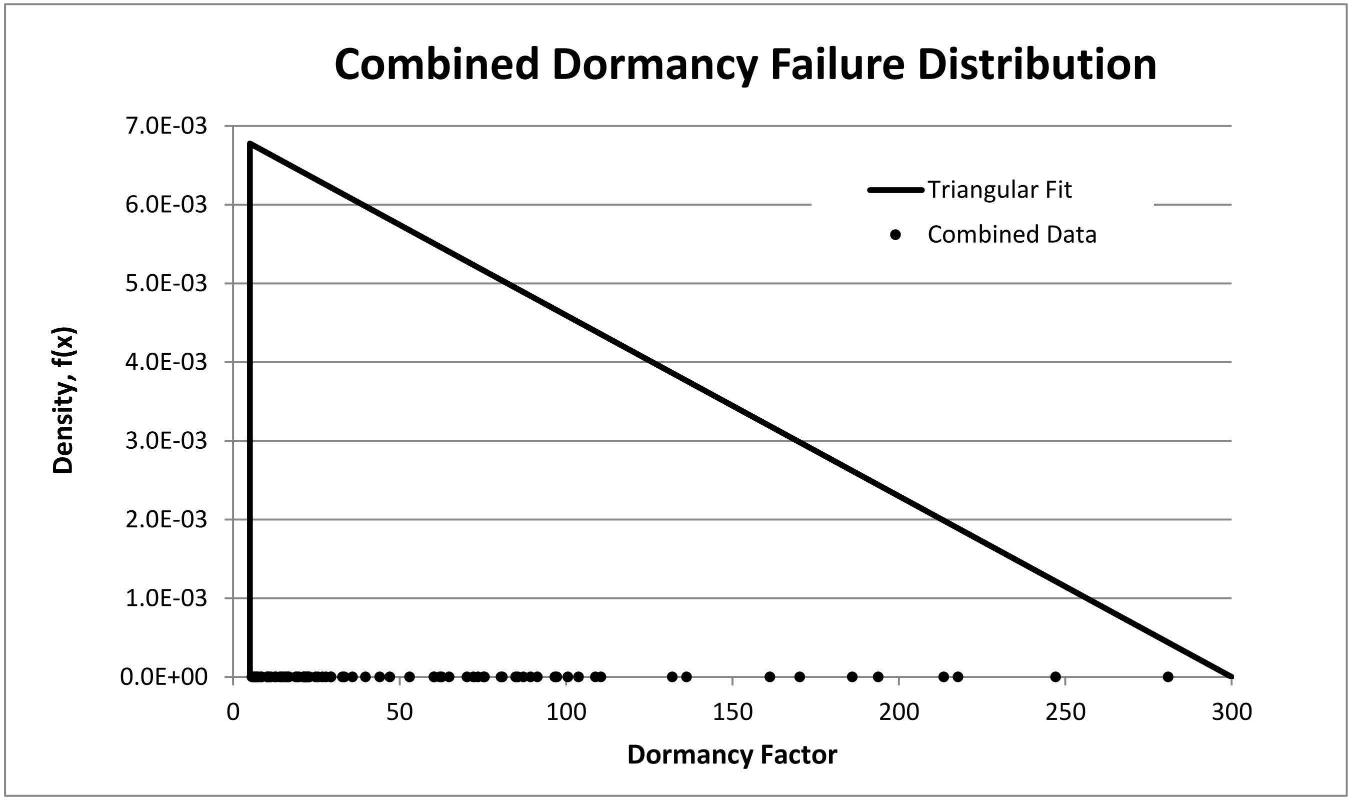
Dormancy Factors

The dormancy factor is the ratio of the dormant failure rate to the combined active failure rates:

$$d = \frac{f_{Active}}{f_{Dormant}}$$

The calculated dormancy factors are then fit to a distribution (in a non-standard way).

To focus on the central tendency of the data, only the 10th to the 90th percentiles are used.



Dormancy Factors—Continued

Electrical items are more susceptible to dormancy failures.

Combined Means by Hardware Type

Hardware Type	Mean Dormancy Factor
Electrical	50
Mechanical	310
Electro-Mechanical	110
Combined	100

Recommendation: Include uncertainty in the form of a (right) triangular distribution.

Triangular Distribution Details

Hardware Type	Minimum	Mode	Mean	Maximum
Electrical	2	2	50	150
Mechanical	10	10	310	900
Electro-Mechanical	10	10	110	300
Combined	5	5	100	300

Using the Dormancy Factors

To model dormant failures using dormancy factor, you need:

1. The active failure rate
2. The dormant duration

The **dormant failure rate** is the active failure rate divided by the dormancy factor:

$$f_{Dormant} = \frac{f_{Active}}{d}$$

It is important to capture the correct dormant time. In some cases the dormant time could go back as far as the date the item was manufactured. In general, dormant time is months or years.

Also, there might be compounding factors (corrosion, thermal stress, etc.) that would require additional analysis.

Conclusions

- These factors are ballpark estimates
- If you have better data, use it
- Use a reasonable estimate for the dormant period